



**Research.
Innovation.
Impact.**

**HUN
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SPACE-READY SCIENCE EXCELLENCE

Hungarian Research Network





Boundless Collaboration

As President of the HUN-REN Hungarian Research Network, I am proud to showcase the excellence of Hungary's flagship research network, particularly in the field of space science. Our experience in space research spans decades, from the pioneering radar experiments conducted in 1946 by Zoltán Bay, one of the first scientists to determine the Earth-Moon distance with metre-level accuracy to today's manned space missions. Our researchers combine this rich legacy of expertise with state-of-the-art technologies, positioning Hungary as a recognized and respected contributor to the international space research community.

Today, more than 120 dedicated researchers across eight institutes are actively involved in space-related research, covering the full spectrum of space science. Our expertise ranges from complex mathematical algorithms and space chemistry to investigating the effects of long-duration space travel on the human brain. Our objective is to consolidate the vast body of knowledge and potential within our network into a single, unified strategy and to become an indispensable partner in the international space industry value chain.

Scientific research, however, represents only one dimension of our competencies. We also possess extensive experience in bridging scientific discovery and innovation, translating research results into practical applications that deliver tangible benefits in everyday life.

This publication presents our most significant achievements, demonstrating how our research network serves as a unified platform for science, development, and industry.

I encourage you to explore Hungary's spirit of innovation and to join us in shaping the next chapter of space exploration. Together, we can advance scientific progress more effectively and, through it, contribute to global societal and economic development, delivering tangible valuable results for people all around the world.

Join us on this journey!

Balázs Gulyás

President of the HUN-REN
Hungarian Research Network





Hungarian Research Network

Research – Innovation – Impact

The HUN-REN Hungarian Research Network is the flagship of **Hungary's innovation ecosystem**. The organization brings together **seven research centres, eight research institutes, and 101 supported research groups**, employing 5,000 researchers and experts across the fields of mathematics, natural sciences, life sciences, and SHAPE (Social Sciences, Humanities and the Arts for People and the Economy). Its primary mission is to foster **curiosity-driven discovery and high-impact research**, transforming the knowledge thus generated into long-term social, economic, and environmental value.

The HUN-REN professional community is united by a shared goal: to strengthen the performance-based research network so that it can **address both national and global challenges**. Our work spans the **full spectrum from fundamental research to applied innovation** and aligns with Hungary's innovation strategy and key priority areas, including healthy living, digital transformation, energy and environmental security, as well as security and defence, including space research.

HUN-REN actively collaborates with universities, industrial partners, and international research organizations **to ensure that scientific results lead to practical solutions** and are integrated into value chains as effectively as possible. The network embodies Hungary's centuries-long tradition of scientific excellence, its international openness, and its **culture of collaboration**—strengthening Hungary's role in the global research community.

Since December 2024, HUN-REN has operated as an autonomous legal entity under its own dedicated legislation, ensuring **independence in governance, funding, and research**. This model allows our institutions to pursue world-class scientific activities in an efficient and transparent manner, while fostering interdisciplinary collaboration and **building strong partnerships** with leading international partners.

www.hun-ren.hu/en

Where Ideas Become Reality



Beyond advancing scientific excellence, a central mission of the HUN-REN Hungarian Research Network is to translate cutting-edge research results into innovations and industrial applications.

We apply the same approach in space research and the space industry. Our terrestrial infrastructure, advanced data-processing capabilities, and access to in-orbit testing create a unique environment for rapidly validating theories under real-world conditions.

This publication offers a detailed overview of HUN-REN's wide-ranging space research activities. Allow me to highlight just one example. During the Axiom-4 mission in the summer of 2025, Hungarian research astronaut Tibor Kapu conducted a unique pharmaceutical experiment. By conducting crystal structure analysis in microgravity, he produced data for the biotechnology sector that cannot be generated under terrestrial conditions, helping to accelerate drug development. This was just one of the 25 experiments he carried out during the mission—and only one example of the many international space missions to which Hungarian researchers have contributed.

Our mission-driven approach aims not only to support fundamental research, but also to provide a strong technological foundation for the more than 100 Hungarian companies active in the space sector, as well as for all interested international partners. We believe that, through our expertise, infrastructure, and extensive national and international partnerships, we can be a trusted, value-adding partner for both established and emerging players in the global space industry.

Let us work together to ensure that today's scientific research becomes tomorrow's innovation and, in time, a practical application that delivers measurable competitive advantage.

Roland Jakab
Chief Executive Officer of the HUN-REN
Hungarian Research Network



The background of the page features a composite image. On the right, a close-up of an astronaut in a white space suit with a reflective visor is shown against a starry space background. On the left, a satellite with four solar panels is orbiting in space. At the bottom, the blue and white horizon of the Earth is visible.

Hungarian to Orbit

Hungary achieved a milestone in human spaceflight through the HUNOR (Hungarian to Orbit) Programme, sending a human into space once again after forty-five years. **Research astronaut Tibor Kapu**, as a member of Axiom Space's **Axiom Mission-4 (Ax-4)**, spent 20 days, 2 hours and 59 minutes in space aboard the International Space Station, carrying out experiments developed by Hungarian universities, research institutes, and companies. During the mission, **trained research astronaut Gyula Cserényi** supported on-orbit activities from the mission control centre in Houston, working closely with the research and development team.

The mission was of outstanding significance for Hungarian science, enabling the implementation of more than two dozen **Hungarian-developed experiments in space**. The research programme spanned a wide range of scientific disciplines, including biology, radiation science, life sciences, fluid physics, plant cultivation, and Earth observation. The unique conditions of microgravity and the space environment made it possible to investigate processes that cannot be studied on Earth, or only to a limited extent. As a result, the **participating research teams gained valuable experience**, enhancing the international competitiveness of Hungarian scientific institutions and companies.

Through the HUNOR Programme, Hungary has once again become **an active participant in manned spaceflights**. The mission also strengthened international cooperation in this field. Furthermore, the domestic selection of astronauts has enabled Hungary to acquire the professional expertise and institutional capability necessary to choose future astronauts.

The logo for the HUNOR programme, featuring the word "HUNOR" in a bold, sans-serif font with a stylized swoosh element under the letter "O".

HUNOR

A portrait of Tibor Kapu, a research astronaut, wearing a dark blue flight suit with patches. He has short dark hair and a beard, and is standing with his arms crossed against a plain grey background.

Trust, Science and Inspiration

On 25 June 2025, forty-five years after Bertalan Farkas became the first Hungarian to travel into space, a Hungarian astronaut—myself—once again journeyed beyond Earth. This mission was not merely a personal milestone; it marked the fulfilment of several years of collective Hungarian scientific endeavour, while also heralding the beginning of new lines of research.

The 25 experiments I conducted aboard the ISS were developed by Hungarian research institutes, universities and enterprises. Spanning ten scientific disciplines, each investigation sought to address the most pressing challenges of long-term spaceflights: how physical and biological processes operate in microgravity; how food might be cultivated during long missions; and how human beings can be protected from prolonged exposure to radiation.

Perhaps the greatest responsibility I bore was knowing that researchers had devoted years to the projects entrusted to me. They placed their confidence in me, and I was determined to prove worthy of that trust. It was this shared sense of responsibility and mission that ensured the success of all 25 experiments.

Human spaceflight demands extraordinary effort, yet its inspirational power is equally remarkable. The researchers involved have gained renewed momentum and are eager to continue, while others—encouraged by their example—are keen to participate in future missions. The same inspiration is evident among young people: in ten to fifteen years' time, they will carry forward the projects and discoveries initiated today. For this reason, I sincerely hope that the next Hungarian space mission will take place in the near future.

Tibor Kapu

Research Astronaut
HUNOR Programme



Hungarian Research Network at the Forefront of Space Research

The HUN-REN Hungarian Research Network and its affiliated institutions play a **prominent role in both national and international space-related scientific research** and industrial cooperation. Hungarian research institutes and research groups—often working in partnership with domestic universities and companies—contribute actively to a **wide range of European and global projects**, including programmes of the European Space Agency (ESA). These include missions such as SMART-1, JUICE, Ariel, Gaia, Comet Interceptor, Lunar Gateway, as well as MOSAIC, REMOTELL, FARBES, ESA PLASMA, PRODEX, and ARMADA.

Through their own research activities and extensive international cooperation, institutions within the HUN-REN network have built a remarkably **broad and deep base of expertise**. Hungarian actors have **achieved significant results** in the development and operation of small satellites, the design of onboard instruments, participation in interplanetary missions, Earth observation, materials science, and research into space weather and space radiation. They have also made important contributions to radiation measurement technologies.

To accelerate further achievements, HUN-REN has **launched its comprehensive Space Research Programme**. Through its implementation, the knowledge embedded within the research institutes is being consolidated into a single, robust strategic framework, **strengthening Hungary's position** within the global space research innovation value chain.

Hungary's space research and space industry possess all the essential foundations for success: **outstanding researchers, modern infrastructure, strong integration** within national and international scientific and industrial ecosystems, and, not least, **recent in-orbit experience**. Hungary and HUN-REN stand ready to offer these capabilities to all international partners whilst particularly **seeking collaboration opportunities** in Central and Eastern Europe.



SPACE SUMMIT '26

Budapest, Hungary

Four Space Travellers at One event

With more than 100 participants, the HUN-REN Hungarian Research Network hosted its first space research conference, launching what is intended to become a new tradition: Space Summit 2026. The event provided a platform for leading HUN-REN institutes and university research groups active in space science to showcase their work and achievements.

One of the highlights of the conference was a video address by Charles Simonyi,



the Hungarian-born pioneer of space tourism and the first space tourist to travel to space twice, who greeted the participants remotely. A panel discussion brought together three astronauts: Tibor Kapu, who visited the International Space Station (ISS) last year as part of the Axiom-4 mission; Bertalan Farkas, the first Hungarian astronaut, who flew to space in 1980; and Sławosz Uznański-Wiśniewski, another crew member of the Axiom-4 mission.



During the event, the HUN-REN Hungarian Research Network announced its new space research programme, which will integrate institute-level research activities into a single, coherent strategic framework. The next Space Summit conference - featuring an expanded programme for both domestic and international audiences—will take place in Budapest in March 2027.



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SPACE SUMMIT '27

Budapest, Hungary

Exploring Space and Research Together

From lab to launch: collaborate,
innovate, and lead the next frontier.



Next year join the minds building
tomorrow's space ecosystem.



„Space Research Is Not a Luxury”



Charles Simonyi

Software Architect, Businessman,
and Space Tourist

Charles Simonyi is the second Hungarian to have travelled to space, 27 years after Bertalan Farkas's historic 1980 mission. He gained international recognition at Microsoft, where he led the teams developing the Word and Excel software programmes. He was the fifth space tourist worldwide and the first to travel to space twice, spending more than 26 days aboard the International Space Station (ISS).

Charles Simonyi addressed the participants of the Hungarian Space Summit 2026 in a video message. Below is an edited version of his remarks.

'Based on my experience, space research is far more than technology. When I travelled twice to the ISS, I saw firsthand that space programmes represent the most complex forms of global cooperation—they would not exist without the coordinated efforts of science, industry, and government.

It is particularly inspiring to see Hungary's current ambitions and Tibor Kapu's mission, which has opened a new chapter in the nation's space activities. The HUNOR programme and the participation of a Hungarian astronaut in international missions demonstrate that Hungary is capable of forging an autonomous, strategic space programme.

Today, space research is a strategic industry. It is no longer only about rockets and satellites, but about the data economy, communications, artificial intelligence, and technologies that impact every sector of the economy. This is why the development of a Hungarian scientific space programme is of particular importance.

The countries that succeed will be those that treat research, engineering mindset, and creativity as strategic resources. Hungary has strong scientific traditions and now has the opportunity to organise these into an internationally competitive space strategy.

And perhaps most importantly: space inspires. It inspires researchers, engineers, students, and entrepreneurs alike. A strong space programme provides not only technology, but vision for a nation.

I believe that space research is not a luxury, but an economic and societal necessity. Hungary stands ready to play an active and pivotal role in the space economy of the 21st century.'





Research Centres and Institutes

**HUN
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Space Astronomy and Planetology

HUN-REN RESEARCH CENTRE
FOR ASTRONOMY AND EARTH
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The **HUN-REN Research Centre for Astronomy and Earth Sciences (CSFK)** plays a significant role in international space research. Its competencies provide excellent opportunities for exploiting the synergies of terrestrial and space laboratories.

At the Konkoly Thege Miklós Astronomical Institute, **space astronomy research** is conducted primarily in connection with past and current missions of the European Space Agency's Science Programme. Researchers at the institute actively contribute to projects such as the **Herschel Space Observatory, Gaia, CHEOPS, JUICE, PLATO, ARIEL, and Comet Interceptor**. Through these activities, the institute has established productive industrial collaborations with Hungarian space companies.

Beyond space astronomy, researchers at CSFK's GeoLab are also involved in international collaborations in **planetary defence, as well as lunar and Martian planetology**. Their work includes supporting the planned drilling activities of the ExoMars rover and conducting laboratory analyses of meteorite samples.

The centre has also achieved notable success in the **development of small satellites**. Hungary's first astrophysical satellite, GRBAlpha—designed and built at CSFK to monitor gamma-ray bursts—operated in low Earth orbit between 2021 and 2025. Its successor, **GRBBeta**, was launched in 2024 as part of a Hungarian-Czech-Slovak-Japanese cooperation and remains operational, focusing on the **investigation of high-energy astrophysical phenomena**.

CSFK has also achieved major advances in the **application of artificial intelligence**. Machine learning methods developed at the centre have enabled researchers to detect stellar outbursts, **classify nearly two billion stars** observed by the Gaia space telescope, and develop data analysis strategies for the forthcoming Vera C. Rubin Observatory **LSST sky survey**. These tools are also being used to analyse cosmological models and to map interstellar and geoscientific structures in unprecedented detail.



Space Dosimetry and Space Radiation Research

HUN-REN CENTRE FOR
ENERGY RESEARCH

The Space Research Department of the HUN-REN Centre for Energy Research (HUN-REN EK) is an internationally recognized centre of excellence in **space dosimetry**. Work in this field began in the 1970s, and the first dosimeters developed at the institute were deployed onboard spacecraft as early as that decade.

The department's expertise in dosimetry encompasses a broad range of competencies, including the mapping of spatial dose distribution within spacecraft, radiation dose monitoring, and **personal dosimetry**. A particular distinction of the department is the application of anthropomorphic phantoms (human-shaped models) to measure radiation **dose distribution within the human body**.

These activities are supported by ongoing methodological and instrumentation development. Since 2003, the department's **PILLE dosimetry system** has been part of the International Space Station's (ISS) service infrastructure. It remains the only device capable of measuring the additional radiation **dose astronauts receive during extravehicular activities**. The department also contributes to continuous radiation mapping within the European Columbus module and supplied dosimeters for the MARE experiment on the **Artemis I mission**.



The Space Research Department also conducts **research in space weather**, focusing on measuring both the composition and energy spectrum of the space radiation environment, as well as variations in the geomagnetic field. It leads the consortium developing the first European **onboard instrument suite for the planned Lunar Gateway** in lunar orbit and coordinates the development of the scientific payload for Hungary's MoonRad satellite. In addition, the department is developing a modular instrument suite for the European Space Agency designed to simultaneously measure ionizing radiation and magnetic field variations in space.

The department's additional activities include **analysing radiation-induced damage** in space, characterizing radiation fields for specific missions and orbits, and performing Monte Carlo-based particle transport calculations to determine total ionizing dose (TID) and the linear energy transfer (LET) spectrum of the radiation environment.

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Space Physics and Space Weather Research

HUN-REN INSTITUTE OF EARTH
PHYSICS AND SPACE SCIENCE



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The core mission of the HUN-REN Institute of Earth Physics and Space Science (HUN-REN FI) is the systemic observation, investigation, and study of natural phenomena **on Earth and in its cosmic environment**. In the fields of space research and space technology, the institute focuses on observing, modelling, and interpreting **Sun-Earth interaction processes** and the state of the near-Earth space environment (Geospace), using both satellite-based and terrestrial instrumentation. The practical application of this expertise includes **space weather monitoring**, the development of **space weather services**, and improved **forecasting capabilities**.

Research activities related to Geospace focus on the analysis of the **dynamics of the magnetosphere-ionosphere system**, with particular emphasis on its interaction with solar radiation and solar wind, as well as on assessing the **impacts of these processes on technological and economic systems**.

The institute operates **extensive measurement networks**, integrated into European and global observation systems, enabling the investigation of **local processes within a broader global context**. HUN-REN FI possesses well-established expertise in the study of the Earth's cosmic environment, covering the **entire chain of coupled processes** from the Sun to surface effects. This integrated approach focuses not only on individual system components but also on the **coupling mechanisms** between subsystems.

HUN-REN FI **cooperates actively** with a range of research institutes and universities and regularly participates in ESA- and EU-funded projects, including ESA MOSAIC, REMOTELL, and the Horizon Europe T-FORS project.

The knowledge gained plays a vital role in protecting and strengthening the **resilience of critical infrastructure** such as power transmission networks, satellite services, GNSS navigation, and radio and satellite communication systems.



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SZTAKI

Earth Observation and Spacecraft Control

HUN-REN INSTITUTE FOR COMPUTER
SCIENCE AND CONTROL

Space-related activities at the HUN-REN Institute for Computer Science and Control (HUN-REN SZTAKI) are addressing both AI-based Earth observation and advanced spacecraft control technologies.

The **Machine Perception Research Laboratory** is currently leading an ESA-supported project, developing a novel methodology for mapping and characterising **areas affected by changing water cover**, with the aim of supporting habitat management and biodiversity protection.

The approach is based on the **effective fusion of satellite and high-resolution airborne multispectral imagery**, applying advanced machine learning, time-series analysis, feature tracking, stochastic multilayer segmentation, and deep neural networks. The system is developed in **close cooperation with national park and agricultural partners** to ensure operational applicability.

The **Systems and Control Lab** contributes to ESA-led **spacecraft technology developments**. The ongoing **MANTRA** project focuses on **mitigating high-frequency microvibrations** in LEO



satellites with optical payloads. By extending the classical Attitude and Orbital Control System with a **dedicated high-frequency control loop**, the project demonstrates significant **reduction of vibration-induced image jitter** through simulations.

The upcoming **ARMADA** project, led by Airbus Defence and Space (France), addresses **robotic manipulation of objects with uncertain dynamics** in space servicing missions, including **active debris removal**. The project develops advanced guidance, navigation, and control strategies combining surrogate modelling, machine learning, and adaptive control. The expected outcomes include **enhanced capture precision**, better handling of large uncertainties and variations of properties, and **increased modularity in servicer architectures**, ultimately delivering more capable and robust space robotic systems.

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Radiation Chemistry and Detection

HUN-REN INSTITUTE FOR NUCLEAR RESEARCH

The HUN-REN Institute for Nuclear Research (HUN-REN ATOMKI) is an **accelerator centre offering transnational access** for users on a various topics from astrophysics to cultural heritage. It provides a unique opportunity to study radiation-induced chemistry in **astrophysical ice analogues**. Its accelerator facilities can serve as solar wind simulators, providing a wide range of ions with energies comparable to those found in the **solar wind and galactic cosmic rays**.

The institute operates five dedicated astrochemistry experimental chambers to investigate **ion-collision-induced molecular destruction**, synthesis, and sputtering processes in astrophysical ice and gas-phase analogues.

These facilities are also well suited for studying **radiation-induced physical and chemical degradation** in materials used in current spacecraft or proposed for future lunar infrastructure. Through radiation chemistry experiments, the **tolerance of space materials to radiation exposure** can be assessed. HUN-REN ATOMKI has participated in several **radiation-hardness testing campaigns**, including contributions to ESA's **SMART-1 mission and the PuliSpace projects**, leveraging its capability to generate diverse radiation types.

In addition, the institute has developed inorganic thin-film scintillators for **radiation detection**. The copper-halide composite scintillator, combined with silicon photomultiplier (SiPM) photodetectors, is particularly advantageous for space applications requiring miniaturized, low-power instrumentation. The system ensures reliable and stable operation even **under harsh environmental conditions**.



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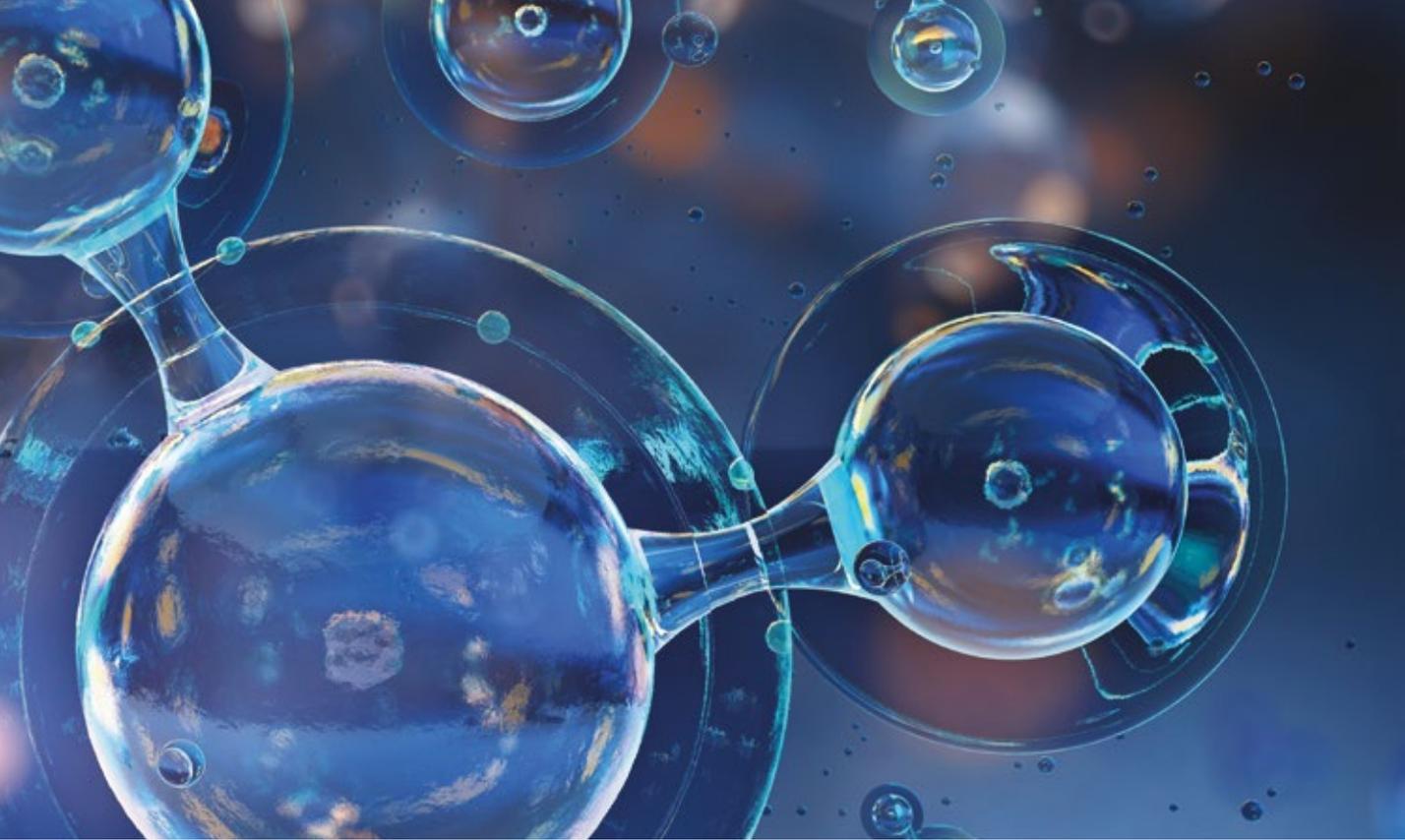
Crystallography and Human Behaviour Analysis

HUN-REN RESEARCH CENTRE
FOR NATURAL SCIENCES

Space-related research at the HUN-REN Research Centre for Natural Sciences (HUN-REN TTK) focuses on two main areas: **crystallization in microgravity** and **studying human behaviour and performance** in space and space-simulation environments.

Researchers at the centre's **Chemical Crystallography Research Laboratory** have developed a novel method for chemical structure analysis and **successfully grown a single crystal aboard the International Space Station (ISS)**.

From an organic molecule, they synthesized a **highly porous hydrogen-bonded organic framework (HOF)**. These materials are structurally analogous to metal-organic frameworks (MOFs), a class of compounds recognized by the 2025 Nobel Prize in Chemistry. Crystallization under microgravity conditions resulted in **significantly improved crystal quality**. The atomic structure of the single-crystal samples returned to Earth was determined using a structural analysis method developed by the team, providing more precise results than previous techniques. This research was carried out through extensive Hungarian and international collaboration within the framework of the HUNOR programme, with the **participation of research astronaut Tibor Kapu**.



Research conducted at the **Environmental Adaptation and Space Research Group** of the Institute of Cognitive Neuroscience and Psychology, HUN-REN TTK focuses on two principal domains.

First, the group investigates **psychodynamic processes in isolated small groups** within terrestrial space-analogue environments and simulation settings. By analysing the diaries of Antarctic overwintering crews, the researchers revealed the emotional, cognitive, and group-dynamic effects of prolonged isolation. Based on these findings, the team is developing an **AI-based automated speech analysis system to monitor psychological adaptation in extreme environments**.

Second, the group examines the effects of **spaceflight-related stressors on cognitive performance** and the brain's electrical activity, both aboard the ISS and in analogue mission environments. Under microgravity conditions, reductions were observed in task performance and in the neural correlates of attentional processes. The research is expected to contribute to the **effective prevention of cognitive problems** that may arise during long-duration missions.

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A full-page background image of an astronaut in a white spacesuit floating in space. The Earth's blue and white horizon is visible in the lower right, and the dark starry expanse of space is in the upper left.

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Inertial Navigation in Microgravity

HUN-REN ALFRÉD RÉNYI
INSTITUTE OF MATHEMATICS

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A research project at the HUN-REN Alfréd Rényi Institute of Mathematics is an excellent example of how **fundamental mathematics and algorithm development** can directly support applied space technology.

The IMU-DRS project at the institute investigates **navigation in microgravity conditions** using data obtained exclusively from accelerometer and gyroscope sensors. Since inertial measurement devices are manufactured and tested under terrestrial conditions, special attention must be given to filtering out the effects of Earth's gravitational acceleration and **examining sensor performance in weightlessness** for space applications.

To support this objective, **Hungarian research astronaut Tibor Kapu** transported a mobile device to the International Space Station (ISS), equipped with a dedicated application developed at the Rényi Institute for this experiment.

In the first phase, calibration measurements were performed with the mobile device in a stationary station, providing **insight into the behaviour of measurement errors**—so-called sensor noise—under microgravity conditions.

In the second phase, the astronaut executed predefined motion sequences while the onboard sensors in the device recorded the data. Preliminary analyses indicate that **sensor measurement errors are reduced** under microgravity conditions. The reconstruction of the trajectories described by the device has since been successfully completed.

The findings may contribute to **improved inertial navigation in space**, the coordinated operation of multiple spacecraft, and the execution of maintenance activities in orbit.

The primary expertise of the Department of Space Science and Space Technology at the HUN-REN Wigner Research Centre for Physics (HUN-REN Wigner RCP) is **space weather and space plasma physics**. The department's research activities focus on **interactions between the solar wind, heliospheric magnetic structures, and planetary plasma environments**, including magnetospheres, ionospheres, and cometary atmospheres.

The department's activities are closely linked to the **international space missions** of the European Space Agency (ESA) and NASA. Since the 1980s, the department has participated in a range of space missions, **contributing across the full mission lifecycle**—from scientific concept development and instrument design to post-launch data analysis and interpretation.

Through involvement in large international collaborations, the Department of Space Science and Space Technology has made substantial contributions to utilising the scientific discoveries of several missions including **Venus Express, Cassini, Rosetta, Cluster, SOHO, Ulysses, and STEREO**. Its current research activities focus on ongoing missions such as the **Parker Solar Probe** and near-Earth satellites, while staff members serve on the international science teams of ESA missions, including **BepiColombo, Solar Orbiter, and JUICE**.

In cooperation with the HUN-REN Institute of Earth Physics and Space Science, HUN-REN Wigner RCP is a founding partner of the **Zero Magnetic Field Laboratory (ZBL)** located near Sopron, in western Hungary. This unique research facility offers an **ultra-low magnetic field environment**, ideal for high-precision magnetic measurements and enables research into the magnetic cleanliness and **testing of space instrumentation**.





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Space Plasma Physics and Space Missions

HUN-REN WIGNER RESEARCH
CENTRE FOR PHYSICS

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Supported Research Groups



HUN REN

Materials Science and Crystallography

HUN-REN-ME MATERIALS
SCIENCE RESEARCH GROUP

Experts from the joint research group of HUN-REN and the University of Miskolc have been actively involved for more than two decades in European Space Agency (ESA) **microgravity programmes**, with a primary focus on materials science research. The **MICAST** programme—launched in 2000—and the ongoing **CETSOL** programme, running since 2007, bring together nearly twenty research institutes from five countries.

The MICAST project aims to explore **how flow conditions influence the microstructure** formed during the crystallisation of aluminum alloys. In a related context, the CETSOL programme investigates how the so-called columnar crystal structure transforms into an **equiaxed microstructure** (consisting of grains with nearly uniform orientation) under specific solidification parameters. These studies contribute to a more precise understanding and control of the **properties of metallic structural materials**, which is of critical importance for both space and terrestrial industrial applications.

To examine the role of fluid flows, three complementary experimental approaches are employed: **microgravity, normal (terrestrial), and enhanced-gravity experiments**.



Microgravity studies were conducted onboard the International Space Station (ISS), using the Materials Science Laboratory (MSL) Solidification and Quenching Furnace (SQF) in an international collaboration. Terrestrial reference and mirror experiments are carried out in the SGMU laboratory, where world-class equipment enables **directional solidification experiments** under unidirectional heat extraction, with both rotating (RMF) and travelling (TMF) magnetic fields applied.

The scientific results have **direct applications in the space industry**. The research group conducts materials science research, materials testing, design, and development for its space industry partners. In addition, it actively contributes to domestic space industry education through the MSc programme in Space Engineering and the BSc specialisation in Space Technology Materials Engineering at the University of Miskolc.

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HUN REN

Stellar Astrophysics

HUN-REN-SZTE STELLAR
ASTROPHYSICS RESEARCH
GROUP



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The HUN-REN–SZTE Stellar Astrophysics Research Group was established in 2022 at the University of Szeged (SZTE) to study peculiar, **interacting binary and multiple stellar systems**, including supernova progenitors, to advance our understanding of **previously unexplored phases of stellar evolution**.

The research group's work relies heavily on observations conducted with **state-of-the-art space telescopes within the framework of international collaborations**. Members of the group have participated in several observation programmes for the **James Webb and Hubble space telescopes** as Principal Investigators (PI) and Co-Investigators, and they are also internationally recognized experts in investigating the link between supernova explosions and the formation of cosmic dust.

In collaboration with researchers from **NASA's Goddard Space Flight Center and the MIT Kavli Institute for Astrophysics and Space Research**, the research group used photometric data from the TESS space telescope to discover and analyse several unique, peculiar, multiply-eclipsing stellar systems. These include:

- **the most compact known triply-eclipsing triple star system** composed of three massive, hot stars orbiting each other at distances smaller than that between Mercury and the Sun;
- **the first and second known sextuple systems** consisting of three eclipsing binaries;
- some of the most compact **quadruple stellar systems** identified to date.

The analyses were supported by proprietary software packages developed by the group.

In addition, the research group conducts critically important activities for the space industry within the framework of the EON project, focusing on the **optical tracking and cataloguing of satellites and space debris**. For this purpose, they utilize the optical tracking telescope installed in Baja, southern Hungary.

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Space Plasma Wave Research and Space Weather Modelling

HUN-REN-ELTE SPACE RESEARCH GROUP



The core expertise of the HUN-REN-ELTE Space Research Group at Eötvös Loránd University includes **theoretical wave propagation in magneto-ionic media, space plasma physics, space weather, and space safety.**

The group has led the development of the **Signal Analyzer and Sampler (SAS) plasma wave instrument family** for space weather-dedicated satellite missions. These instruments have been successfully deployed in several space missions since 1989. The **latest generation, SAS4**, is designed to identify and analyse wave phenomena fundamental to wave-particle interactions in Earth's radiation belts. The instrument has recently been **pre-selected in an ESA PRODEX call.** The recently concluded Horizon Europe **FARBES project**, coordinated by the group, developed a **scenario-based radiation belt forecasting model.** The model provides clear and operationally relevant responses to current space weather events, delivering directly actionable information for satellite operators.



Within the ESA PLASMA project, the group developed plasmaspheric data products, including **electron density distributions and plasmopause maps**. These datasets are publicly available through the **ESA Space Weather portal** and enhance monitoring of the near-Earth plasma environment.

In an ongoing ESA PRODEX project, the group is investigating the feasibility of **deploying an active, very low frequency (VLF) transmitter** onboard a satellite to probe the plasmasphere, ionosphere, and radiation belts. In parallel, the group has established and leads a unique **global VLF receiver network (AWDANet)**, supporting integrated ground-space observations.

Contact

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HUN-REN Research Centres, Institutes, and Supported Research Groups Engaged in Space Research



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